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Spruce Budworms
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Spruce Budworm Viruses

Four different types of viruses have been found in populations of spruce budworm, *Choristoneura fumiferana*, and western spruce budworm, *C. occidentalis*. All four viruses have one feature in common: virus crystalline particles within inclusion bodies. These are sufficiently large to be visible through a light microscope, making them easy to recognize. When these inclusion bodies are ingested by a spruce budworm larva, the matrix protein dissolves in the alkaline gut juices, liberating the virus particles. Some of these particles attach to gut cell membranes, and a cycle of penetration, replication, and maturation commences.

The four types of viruses are illustrated in plate 1. Nuclear polyhedrosis virus (NPV) inclusion bodies, which are 1.0 to 1.5 μm in diameter, contain bundles of rod-shaped virus particles (Fig. 1). Their nucleic acid is DNA and they replicate in the nuclei of gut, fat body, blood, muscle, and hypodermal tissues as NPV, but in the cell cytoplasm as well as the nuclei. Like NPV, the virus particles are rod-shaped and the nucleic acid is DNA. However, there is only one virus particle per inclusion body, which is about 0.5 x 0.2 μm and is called a capsule. Cytoplasmis polyhedrosis virus (CPV) has inclusion bodies which are slightly smaller than NPV (Fig. 3). The virus particles are spherical, contain segmented RNA and replicate in the cytoplasm of gut cells. Larvae which are heavily infected with this virus die from starvation. Entomopoxvirus (EVP) inclusion bodies (Fig. 4) are oval and larger than the other viruses, ranging in size from about 3.0 to 12.0 μm x 2.0 to 8.0 μm. The virus particles are oval, have a mulberry-like surface structure, contain DNA, and replicate in the cell cytoplasm of all tissues except the germ cells. These viruses must first be ingested by larvae in order to initiate the infection process; therefore adult moths cannot become infected. However, if larvae are only lightly infected, they can develop into pupae and then adults, and virus replication can occur in both these stages. Transmission of virus inside eggs or on their surface has not been demonstrated with any budworm viruses.

Viruses found in other species of budworms, such as the two-year cycle budworm, *C. biennis*, the Modoc budworm, *C. viridus*, the jack pine budworm, *C. pinus*, and the large aspen tortrix *C. conflictana*, are generally cross-infectious to spruce budworm larvae, and a considerable collection of virus isolates has been amassed. The highest levels of naturally occurring virus disease (20 to 30% of larvae) found in the field, were EPV in two-year cycle spruce budworm and GV in western spruce budworm. In the eastern species, extensive surveys have shown levels of NPV and CPV usually at less than 1%. Collapse of a spruce budworm population due to a virus epizootic, or due to any other pathogen, has never been observed.

Viruses only replicate in living cells. A cell culture system is available in which spruce budworm NPV will replicate, but the medium required to maintain these cells is extremely expensive. Therefore, living insect larvae are routinely used for virus production. A spruce budworm larva, which is heavily infected with NPV, will yield 5 x 10^8 polyhedra, but in mass production, this figure falls to a mean of 1 x 10^8. Hence, 7500 larvae were required to produce the dosage used to treat 1 ha (2.5 acres) in the 1971 and 1977 trials. Production of virus in insect larvae is labor-intensive and therefore costly.

The Forest Pest Management Institute (FPMI), in collaboration with Dr. Gordon Howse, Great Lakes Forest Research Centre, has tested NPV, GV, CPV, and EPV in the field in Ontario, either alone or in combinations, on spruce budworm. Only NVP, to date, has been tested on western spruce budworm in Canada. Virus treatments applied from the air have generally been at bud-flush at the peak of the fifth larval instar. Applications on highly susceptible, second instar larvae have also been tested. Most research efforts have been concentrated on NPV and over 2000 ha (4942 acres) have been sprayed with this virus. Extensive safety testing and biochemical studies have been undertaken with NPV, and little additional information is required should registration of this virus as a biocontrol agent be considered.

The first aerial spray trial using viruses against spruce budworm was conducted in 1971 when a mixture of NPV and CPV (ratio 400:1) at a dosage of 7.5 x 10^{11} polyhedra/ha was applied. An EPV was also tested in 1971. Good population reduction was recorded with the NPV-CPV mixture, and the NPV persisted in the budworm population for over 5 years. It is thought that viruses are carried over from year-to-year in cadavers, which remain over winter webbed-up on foliage.

The EPV was tested again in 1972 with 512 ha (1265 acres) treated. As better carry-over from year-to-year was recorded with NPV, tests with EPV were suspended at this time. Between 1972 and 1977, reduced dosages of NPV were tested, with evaluation of such parameters as timing of application, volume emitted, tank-mix, and spray equipment. Although some satisfactory initial levels of population reduction were achieved, foliage protection was disappointing because the persistence of virus from one year to the next was low. In 1977, the high dosage used in 1971 was retested, and 92% population reduction due to treatment (modified Abbott's formula) was recorded on white spruce trees. In 1978, the 7.5 x 10^{11} polyhedra/ha dosage was applied on six plots at the peak of the fifth instar. Population reductions due to treatment on white spruce ranged from 33% to 92% and on balsam fir trees from 37% to

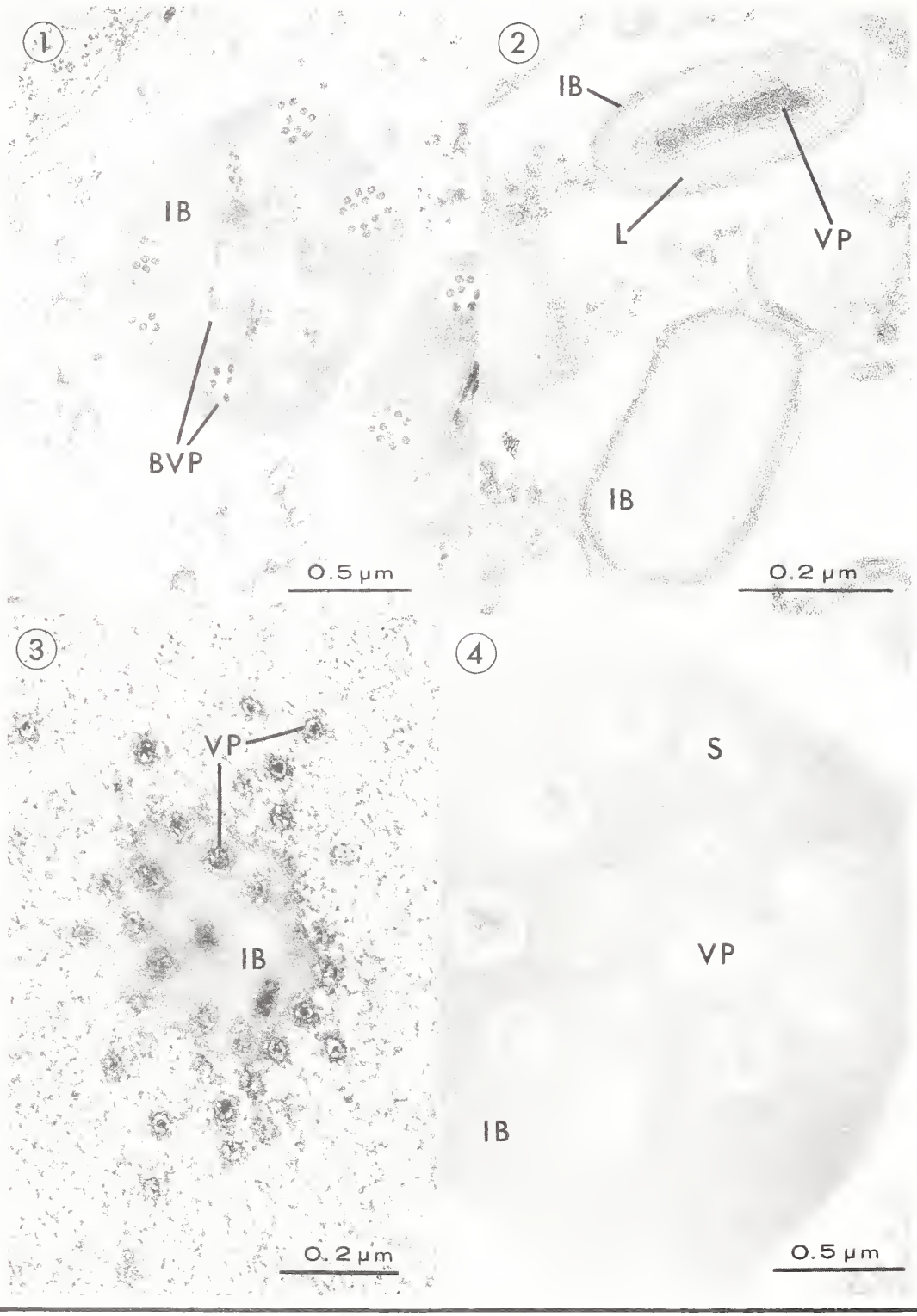

Plate I

Figs. 1-4: Electron micrographs of ultrathin sections of viruses found in spruce budworms. When virus development is complete, virus particles (VP) are occluded in proteinaceous inclusion bodies (IB). Fig. 1. Nuclear polyhedrosis viruses contain bundles of rod-shaped virus particles (BVP). 48,000X. Fig. 2. Granulosis viruses contain only one virus particle per inclusion body. At high magnification, the macromolecular crystalline lattice (L) of the inclusion body protein can be seen. 150,000X. Fig. 3. Cytoplasmic polyhedrosis virus with spherical virus particles in and around a developing inclusion body. 116,000X. Fig. 4. Entomopoxvirus. The virus particles which have a mulberry- shaped surface structure. The inclusions also contain spindle-shaped protein bodies (S) which are not infectious. 51,000X.

76%. Generally, a higher virus kill has been found on white spruce than on balsam fir. In all trials conducted between 1971 and 1978, foliage protection was negligible during the year of application although some foliage protection was recorded in a few of the plots in subsequent years.

In 1979, a mixture of NPV and CPV (178:1) was retested on two plots at a dosage of 7.5×10^{11} polyhedra/ha, this time on second instar larvae as they emerged from hibernacula. GV was also tested for the first time in an aerial application, but was applied on fifth instar larvae at budflush. In spite of the low level of CPV in the mixture, this virus was more prevalent than NPV in treated larvae. Population reductions due to treatment were recorded at 50% and 85% on balsam fir and 45% and 81% on white spruce trees. For the first time, significant foliage protection was recorded during the year of virus application, with 78% foliage saved on balsam fir and 68% on white spruce in one of the plots. In the other, 43% of foliage was saved on balsam fir and 39% on white spruce. GV at 2×10^{14} capsules/ha (7500 GV-infected larvae) gave 74% population reduction due to treatment on white spruce hosts, with 17% foliage saved.

FPMI, in collaboration with staff of the Pacific Forest Research Centre and British Columbia Forest Service, conducted trials in 1977 and 1978 in British Columbia using NPV against western spruce budworm on Douglas-fir. The trial in 1977 was a failure because the virus dosage was too low and was applied too late. However, in three 20-ha (50-acre) plots treated at budflush with 7.5×10^{11} polyhedra/ha in 1978, 48% population reduction due to treatment was recorded in one plot 15 days after spraying, 26% in the second, and none in the third that had a low population density and was abandoned for follow-up studies. In 1979, high levels of virus disease were found in the two plots and budworm population densities were about half those recorded in check plots. In 1980, NPV was still present in the budworm population, but larval numbers had increased greatly and exceeded those in the check plots. This was probably due to immigration from the high populations which surrounded these small plots. An aerial spray trial, planned for 1980 by staff of the USDA Forest Service Laboratory at Corvallis, Oregon, to compare the efficacy of NPV and GV on western spruce budworm, was postponed. It is hoped that this test will be conducted in 1981.

GV is much slower in killing budworm larvae in the laboratory than NPV and has not received as much attention as the latter virus. There is a great lack of information on the ecology of all these budworm viruses, and when the interaction of virus, host, and forest ecosystem is considered, it may be that the best biocontrol agent is not necessarily the most virulent virus.

Unless more virulent ones are found, it may be unrealistic to expect viruses to provide a complete solution to the spruce budworm problem. Viruses have been used successfully for control of Douglas-fir tussock moth, gypsy moth, and two species of sawflies, but in all these cases, virus production is economically feasible, and efficient year-to-year virus transmission mechanisms exist. The best we can expect from the viruses currently available, in terms of spruce budworm control, is their use on high value stands and ecologically sensitive areas. Research continues with the following priorities: 1) A search for new, more virulent viruses, 2) A search for an alternative insect host, larger than spruce budworm, for virus production, 3) A study of improved tank-mixes which will maintain viruses in a viable state on foliage for a longer period of time, and 4) A detailed investigation of viral nucleic acids with a long-term goal of manipulating them genetically in order to enhance virulence.

Scientists in the U.S.A. involved in spruce budworm virus research include USDA Forest Service (Research) teams at Corvallis, Oregon and Hamden, Connecticut; Dr. Gordon Stairs at Ohio State University; Dr. Martin Shapiro at Otis Air Force Base, Massachusetts; and Dr. Bill Yendol at Pennsylvania State University.

J.C. Cunningham and *J. Percy*—Forest Pest Management Institute, Sault Ste. Marie, Ont.

Forthcoming Meeting

The Fourteenth Annual Northeastern Forest Insect Work Conference will be held February 24-25, 1981, at the Ramada Inn in Bangor, Maine. Tentative program plans are for workshop sessions on tree genetics, seed and cone insects, photography, environmental monitoring techniques, and selected hardwood and softwood insect problems. For further information, please contact either Dr. Mark Houseweart, Conference Coordinator, at 207-581-7273 or Program Chairperson Suzanne Goldman at 207-945-6417.

FPMI Long-Term Environmental Impact Research Program

During the winter of 1979-80, the Environmental Impact Section of the Forest Pest Management Institute, through the cooperation of the Sault Ste. Marie District Office of the Ontario Ministry of Natural Resources, initiated a research program in the Icewater Creek watershed, 50 km (30 miles) north of Sault Ste. Marie. The objective of this program is the examination of several aquatic and terrestrial habitats and microhabitats, and their resident populations, to provide baseline data for future assessment of the nature and degree of inherent risk, degree of exposure, and response of the ecosystem to forest pest management strategies involving the aerial spraying of various pesticide substances.

Because each part of the ecosystem is affected in proportion to its individual susceptibility and level of exposure to the pest control tactics and substances in

use, the first two phases of the program will attempt to define these key areas of potential hazard. The program's third phase will test actual responses and will clarify the nature of ecosystem responses to various impact intensities. This will require relating of impacts at lower trophic levels, or among specific groups of organisms, to secondary impacts at higher trophic levels, and assessment of changes within the ecosystem, such as alterations in food supply or in such basic processes as predation or pollination.

During each of the program's three phases, all environmental impact-related studies will consider the possible effects of the variables inherent in any pest control operation. These include the timing of pesticide applications, the application methods, formulations and equipment involved, and the type of pesticide substance(s) employed.

The program will make it possible, in large measure, to define and predict the environmental consequences of any given pest management activity or strategy, regardless of the time of year, pest species, life stage of a particular pest species, or geographic area involved. The effects of geographic location on timing and seasonal development will be minimized by relating sampling activities and findings to the phenological development of various tree species, pollen sources, target insect species and other biological groups, and to the measurement of accumulated heat units. The findings of the program will be applicable, in both a predictive and a dynamic sense, to operational pest control programs and will permit the testing and verification of environmental impact data generated under experimental conditions or by the monitoring of operational pest control activities.

Data collection was initiated in the study area during the spring of 1980, with the objectives of describing the types of fauna and habitats available for study and of testing the suitability of various sampling techniques for collecting data on a long-term basis. Meteorological and phenological factors were monitored throughout the season to complement the biological information gathered.

The monitoring of population and activity levels will continue during 1981. Experiments are tentatively planned for the latter part of the year to measure ecosystem exposure to aerially applied treatments, using suitable tracers and diluents to simulate aerial sprays.

Questions on the program should be directed to Peter D. Kingsbury, Forest Pest Management Institute, P.O. Box 490, Sault Ste. Marie, Ontario, P6A 5M7.

Developments Concerning The Use Of *Bacillus thuringiensis* For Control Of Spruce Budworm

It has long been known that *Bacillus thuringiensis*, B.t., can have a lethal effect on larvae of the spruce budworm. This bacterium specifically affects lepidopterous larvae and has been tested without adverse effects on other insects, plants, animals, and man. Moreover, there are nonpollutant and environmentally safe B.t. formulations.

For many years, the Insect Pathology Unit of the Laurentian Forest Research Centre (LFRC) of Environment Canada at Quebec City has been engaged in evaluating the possibilities of using B.t. operationally against the spruce budworm. This research has resulted in the development of a B.t. formulation with the required dosage (20 billion I.U./ha), which can be economically applied in aerial spray operations at the maximum dispersal rate of 4.7 L/ha (0.42 imp. gal./acre), i.e., 16 billion viable spores per tree. This formulation contains B.t., an anti-evaporant, small quantities of the enzyme chitinase which increases B.t. activity, and a sticker to fix the spores on foliage.

The Insect Pathology Unit of LFRC has carried out many experimental and operational aerial treatments with this B.t. formulation, and the results have proved its efficacy. The Quebec Department of Energy and Resources has successfully used it for several years in aerial spray operations, using a DC6B equipped with a 11 700 L (2574 imp. gal.) reservoir which enables the aircraft to treat 2500 ha (6178 acres) per flight. The satisfactory results of these aerial spray applications by Quebec have eliminated most of the unjustified criticism of B.t. Nevertheless, the delivered dosage (4.7 L/ha) of the formulation is twice that of chemical insecticides; the latter are applied at a rate of 2.36 L/ha (0.21 imp. gal./acre) annually over the same area in two applications of 1.18 L/ha (0.105 imp. gal./acre) each. However, the advantage is still in favor of B.t. because it requires only one application which means saving time, money, and energy.

In 1979, the Insect Pathology Unit of LFRC, under the direction of Dr. W.A. Smirnoff, carried out a series of special trials with an aircraft and different B.t. formulations to determine the principles and fundamental mechanisms governing aerial spraying with B.t. The principal aim of these trials was to find out how to group the greatest number of spores possible in the smallest volume of liquid, and thereby reduce the cost of B.t. This work resulted in the development of a B.t. formulation which provided the required dosage at the reduced rate of 2.5 to 3.0 L/ha (0.22 to 0.27 imp. gal./acre).

A series of experimental aerial spray operations with this formulation were carried out in 1980 over several hundred hectares of spruce budworm infested forest. A Grumman AgCat equipped with a standard boom and spray nozzle system was used to apply the B.t. at the rate of 2.5 L/ha. Results obtained were satisfactory; each tree received an average of 1 to 1.5 million B.t. droplets, i.e. 16 billion spores. The treatments resulted in high larvae mortality and good foliage protection.

From left to right: Dr. W.A. Smirnoff and his team — Messrs. D.S. Langlois, J. Valéro, and A. Juneau.

Recent Budworm Outbreak

The Northeastern Area—Forest Insect & Disease Management reports increased budworm activity on the Nicolet National Forest. Seven high value white spruce plantations were intensively surveyed and found to be moderately to severely damaged. The report includes recommendations for plantation treatment. One of the plantations, moderately defoliated, is considered a candidate for B.t. treatment. Copies of the report (NA-FR-1) can be obtained from Northeastern Area, State and Private Forestry, USDA-FS, 370 Reed Road, Broomall, Pennsylvania 19008.

Spruce Budworm Damage Studied

Dr. René Alfaro, recently appointed research scientist at the Pacific Forest Research Centre in Victoria, B.C., is currently analyzing some 10 years of accumulated data on the effects of western spruce budworm on Douglas-fir in British Columbia.

Preliminary results indicate some clearcut relationships between defoliation, tree mortality, and growth loss. Dr. Alfaro thinks this information will contribute to a much clearer understanding of how severe the losses resulting from different intensities of defoliation are, and therefore, could be used in management decision-making.

CANUSA-East Program Presentation

CANUSA-East Program Management has prepared a comprehensive review package for oral presentation featuring current status and anticipated future direction of the Program. On request, the Program will be presented to public sector agencies interested in the budworm situation or to responsible organizations with similar interests. For example, a meeting was held September 11, 1980, in Bangor, Maine for this purpose at the request of the Commissioner of Natural Resources for the State of Maine. Requests should be sent to: Dr. Daniel M. Schmitt, Program Manager, CANUSA-East, USDA-FS, 370 Reed Road, Broomall, Pennsylvania 19008.

Canada/U.S. Joint Registration Of Insecticides

In CANUSA Newsletter No. 7, we reported that an ad hoc committee had formed to look into the feasibility of sharing or exchanging data to expedite registration of budworm control materials in both countries. Through the efforts of Bob Lyon (FIDR, USDA Forest Service), the committee has assembled a list of insecticides which appear to have the greatest potential for joint registration. The committee has no involvement in the registration process. The next move is for insecticide manufacturers to provide data to support registration of new products in either or both countries.

Spruce Budworms Thesaurus

This thesaurus, intended for use with the Spruce Budworms Bibliography, is available from CANUSA-East Spruce Budworms Program, Northeastern Forest Experiment Station, 370 Reed Road, Broomall, Pennsylvania 19008. It is not available from Malcolm Hunter at the University of Maine as stated in Newsletter No. 10.

CANUSA R&D Management Inventory

Issue No. 4 of the Inventory has been distributed to investigators and to Program Management offices in the United States and Canada. Delivery was intended to precede the eastern and western working group meetings so that all investigators would be fully prepared to "communicate, cooperate, and coordinate." However, Murphy's law was in effect again as evidenced by various delays in processing and by a postal service strike in some areas.

This issue contains 336 studies or projects (up from 308 in April 1980) involving 304 investigators (up from 294). Unfortunately, we know that there are many other studies being conducted by scientists who could be benefiting from information shared through the inventory.

For the first time all investigators in current studies were provided with the complete file of information, i.e. the Basic Record as well as several indices to its content.

Slide Collection

CANUSA-East Program Management has accumulated a collection of about 200 2x2 color slides that illustrate the activities associated with spruce budworms and spruce-fir forest management. Although the collection is not complete, CANUSA-East is still interested in trading slides and is willing to make short-term loans for special purposes. Anyone interested in receiving the slide catalogue should write to Dr. Robert Talerico, Research Coordinator, CANUSA-East Program, USDA-FS, 370 Reed Road, Broomall, Pennsylvania 19008.

Requests For Proposals

Requests for proposals for funds available in FY 1981 were mailed October 31, 1980. The due date for return was December 8, 1980 and the Technical Review Panels met January 27-29, 1981. Decisions will be made soon so that successful applicants can have early access to funds.

FY 1980 Awards For RD&A Work

The following studies were approved in 1980 for funding from CANUSA-West.

Study Title	Principal Investigator	Funding Agency
"Taxonomic Relationships and Pheromone Isolation Among Western Spruce Budworm"	Jerry A. Powell	SEA-CR
"Relationships Between Spruce Budworm Population Vigor Categories and Chemical Constituents of Larval Tissues"	Milena J. Stoszek Karel J. Stoszek	FS
"Development of an Automatic Spruce Budworm Egg Mass Counter"	Daniel T. Jennings MEDC	FS

Personnel

Many of our readers will be saddened to learn that John Walker died of a heart attack this past July. John was head of the Remote Sensing Section, Environmental Sciences Department of the Calspan Corporation, Buffalo, N.Y. As such he was known to many foresters and forest scientists in the Northeast because of the Company's involvement in forest related projects, most recently for CANUSA-East on the use of remote sensing for tree mortality assessment, and for New York State on acid rain.

David Thorud, Director, Northeastern Experiment Station, Broomall, accepted an invitation to participate in the annual University of Maine Forest Service tour of demonstration and research studies in Baxter State Park and surrounding areas. The tour was preceded by an evening "get-together" of key forest industrialists and Maine Department of Conservation officials.

The tour, which attracts substantial numbers of foresters and biologists in Maine interested in the spruce budworm problem, is conducted by University of Maine scientists and Dr. Gordon Mott, Northeastern Forest Experiment Station at Orono, Maine. Gordon and Dr. John Dimond, UMO, are codirectors of a demonstration project funded by CANUSA-East and administered by Northeastern Area—Forest Pest Management (NA-FPM).

Effective January 4, 1981, Dr. Max McFadden will be moving to the Washington Office to become staff assistant for entomology in Forest Insect and Disease Research. Max is leaving CANUSA-West, knowing that it is well on the way to achieving an integrated forest pest management system for western spruce budworm. The program is being managed in the interim by Applications Coordinator Tom Flavell and Research Coordinator Jim Colbert.

Items From The Press

Budworm spray lesser of two evils — The health hazards of insecticide sprays are trivial compared to the devastating effects of massive unemployment that would result if Newfoundland lost its forest industry, Dr. Paul Patey told the provincial royal commission on forest protection and management. "The risk of losing our forestry resource and the subsequent loss of jobs is greater than the risk of toxicity of chemicals," he said. The health hazards of unemployment are self-evident to most physicians, he added.

(Globe and Mail - September 27, 1980)
Toronto, Ontario

N.B. spraying to be selective — The spraying of New Brunswick forests to kill spruce budworm will continue next year but on a more selective basis, Natural Resources Minister J.W. Bird says. Mr. Bird said in his annual report on the spray program that new mapping and spray techniques will allow the anti-budworm spray to be concentrated in areas where it will do the most good. "Up to now we have not had the forest-management tools to make this possible." The minister said the mapping will make it possible to spray specific stands of trees instead of spraying everything in a designated block.

(Globe and Mail - October 16, 1980)
Toronto, Ontario

A Newfoundland logger's union warned recently the province's forests may be a thing of the past unless something is done soon to combat spruce budworm infestation.

Loggers Local 2564 of the International Brotherhood of Carpenters and Joiners said in a brief to a royal commission into forest management here that if the present destruction continues, a catastrophe like one never encountered before may happen. The union recommended a controlled spray program to combat the spruce budworm.

(Halifax Chronicle Herald - September 20, 1980)

Recent Publications

"Spruce budworm and the Elk: Can they live together?" For the answer to that provocative question, consult the June 1980 publication of the Pacific Northwest Forest and Range Experiment Station (809 N.E. Sixth Avenue, Portland, Oregon 97232).

Also from the same source, these two reports: "Larval densities and trends of insect species associated with spruce budworms in buds and shoots in Oregon and Washington," Research Paper PNW-273 by V.M. Carolin.

"Radial growth in grand fir and Douglas-fir related to defoliation by the Douglas-fir tussock moth in the Blue Mountains outbreak," Research Paper 269 by B.E. Wickman et al.

Other reports from various locations are:

From FIDM, USDA-FS, Northern Region, Missoula, Montana 59807:

"Western spruce budworm defoliation trend relative to weather in the Northern Region, 1969-1979," Report No. 80-4 by John S. Hard, S. Tunnock, and R. Elder.

From FIDM, USDA-FS, Pacific Northwest Region, P.O. Box 3623, Portland, Oregon 97208.

"Evaluation of weather patterns in relation to western spruce budworm outbreaks in North Central Washington, 1979-1980," by D.B. Twardus.

From USDA Forest Service, Methods Application Group, 2810 Chiles Road, Davis, California 95616:

"Spray characterization trials for the 1979 Maine spruce budworm control program," Report No. 80-4 by John W. Barry, Imants Millers, and Ernest M. Richardson.

"Prediction of western spruce budworm defoliation on Douglas-fir," Report No. 80-10 by Allan T. Bullard and Robert W. Young, and

"An analytical approach for defining optimum sample size for spray deposit assessment," MAG Report 80-7 by John Wong.

From USDA Forest Service, Northeastern Forest Experiment Station, 370 Reed Road, Broomall, Pennsylvania 19008:

"Foliar nutrient status of young red spruce and balsam fir in a fertilized stand," Research Paper NE-467 by Miroslaw M. Czapowskyj, L.O. Safford, and Russell D. Briggs.

From the Great Lakes Forest Research Centre, Box 490, Sault Ste. Marie, Ontario P6A 5M7:

Chris Sanders has published an overview "Spruce Budworm Control Research: An Update," in the summer 1980 issue of the GLFRC "Forestry Research Newsletter."

Jack Basham presents his "Preliminary report on the rate of deterioration of spruce budworm-killed balsam fir and its relationship to secondary stem insects." Report 0-X-314, May 1980.

From the Forest Pest Management Institute, Box 490, Sault Ste. Marie, Ontario P6A 5M7:

"Report of the 1979 CANUSA Cooperative *Bacillus thuringiensis* B.t. spray trials," edited by Ozzie Morris. FPMI Report FPM-X-40, June 1980.

Two reports from the Newfoundland Forest Research Centre, P.O. Box 6028, St. John's, Newfoundland A1C 5X8:

"Distribution of hibernating spruce budworm larvae within crowns of balsam fir trees in Newfoundland," by B. Moody and I.S. Otvos. Report N-X-182, January 1980.

"The effects of Fenitrothion, Matacil, and *Bacillus thuringiensis* plus Orthene on larval parasites of the spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae)," by I.S. Otvos and Arthur G. Raske. Report N-X-184, May 1980.

The Conservation Council of New Brunswick has released the proceedings of its conference, "Forest Management in New Brunswick." Copies are available ($5.00 individuals, $10.00 institutions) from the Council at 180 St. John Street, Fredericton, N.B. E3B 4A9.

A recent report, "Timber in the United States economy 1963, 1967, and 1972," General Technical Report WO-21 by Robert B. Phelps is available from the Forest Service, U.S. Department of Agriculture, P.O. Box 2417, Washington, D.C. 20013. This may be useful for those working on the economics of budworm-caused impacts.